

LETTERS TO THE EDITOR.

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The Great Submergence.

THE glaciation of the hills and glens all over the west of Argyllshire present phenomena which have for many years convinced me that the chief glaciating agent cannot possibly have been what is called an "ice-sheet." Ordinary glaciers, descending from the hills, have probably been concerned more or less. But the main agency has been, in my opinion, heavy "floe," or floating ice, driven by tides and currents during a submergence and a re-emergence of the land to the extent of at least 1500 feet. The main objection to this view has always been the absence of marine deposits, and especially of marine organisms. It is true that we have very few remaining beds of gravel or sand, and in those, as yet, no mollusca have been discovered. But I have never thought this objection a very strong one, because the submergence may not have been under conditions favourable to molluscan life, and dead shells, carried where they never lived, may easily have long ago been dissolved out. Quite recently, however, shells in great variety have been found at high elevations in Ayrshire, by Mr. Smith, of Kilmarnock. Moreover, these are embedded in the true boulder clay. And where these are wanting, marine microzoa have been detected in abundance by the most skilled and distinguished microscopist of the day. Stimulated by these discoveries, I have lately made a closer search for any remains of loose sands or gravels among our hills. That search has been rewarded by finding a well-marked fragment of an elevated sea-beach at the height of 350 feet above the sea, and in this deposit foraminifera have been found in fair abundance. Another place, quite 500 feet above the sea, has yielded similar evidence; and I have now very little doubt that such evidence will accumulate as the result of further search. This, however, is enough to prove a very recent submergence to a depth which would profoundly alter the distribution of sea and land along all our shores, and would divide the county of Argyll into a group of islands. No reasonable limit can be placed to the possible depth of this submergence. I have no theory as to the causes of it. But it may quite as well have been 1500 as 500 feet; and we must yield to any clear evidence of effects which cannot otherwise be explained. I need not say that the evidence, which in the latest years of his life carried conviction to the mind of the late Sir Joseph Prestwich, that there has been very lately in geological history a great submergence, which was comparatively sudden and comparatively transient, is evidence which no geologist can put aside without the fullest and most candid investigation.

ARGYLL.

The Visibility of a Sound Shadow.

Two months ago I received the following letter from Mr. E. J. Ryves.

"On Tuesday, April 6, I had occasion, while carrying out some experiments with explosives, to detonate 100 lbs. of a nitro-compound. The explosive was placed on the ground in the centre of a slight depression, and, in order to view the effect, I stationed myself at a distance of about 300 yards on the side of a neighbouring hill. The detonation was complete, and a hole was made in the ground 5 feet deep and 7 feet in diameter. A most interesting observation was made during the experiment.

"The sun was shining brightly, and at the moment of detonation the shadow of the sound wave was most distinctly seen leaving the area of disturbance. I heard the explosion as the shadow passed me, and I could follow it distinctly in its course down the valley for at least half a mile: it was so plainly visible, that I believe it would have photographed well with a suitable shutter."

On receiving this note, I asked and obtained permission from Mr. Maxim to be present if a further experiment of the kind were contemplated. I designed and had prepared a special shutter which, on the breakage of an electrical circuit, would in the 40th second make an exposure of about 1/300 second. Unfortunately the battery that I brought with me proved insufficient, so that I had to discard this, and use an ordinary

Thornton-Pickard shutter actuated by hand. Neither the exact moment nor duration of the exposure were under such perfect control, and, as events proved, I could not get the exposure until the shadow had passed me. I had, however, fortunately asked Mr. Paul if he would be so good as to take a picture of the explosion with his animatograph. Mr. Hunt, his manager, came himself, and secured a good series.

Returning now to the eye observation: Mr. Ryves informed me he saw the expanding shadow on an intermediate occasion when only about 10 lbs. were detonated. On the day on which I was present (May 19), about 120 lbs. of nitro-compound were detonated, and 10 lbs. of black powder was added to make sufficient smoke to show on the plate. As the growth of the smoke cloud is far less rapid than the expansion of the sound shadow, no confusion could result from this.

At the time of the explosion my whole attention was concentrated upon the camera, and for the moment I had forgotten to look for the "Ryves ring," as I think it might be called; but it was so conspicuous that it forced itself upon my attention. I felt rather than heard the explosion at the moment that it passed. We stationed ourselves as near as prudence would allow at a distance of 120 yards, so that only about one-third of a second elapsed between the detonation and the passage of the shadow; but the precision of observation of coincidence when very rapid movement occurs is so great, that I am quite satisfied that the observation was correct. The actual appearance of the ring was that of a strong black circular line, opening out with terrific speed from the point of explosion as a centre. It is impossible to judge of the thickness of the black shadow; it may have been 3 feet, or it may have been more at first, and have gradually become less in thickness or, possibly, in depth of shade.

I have some difficulty in understanding why the whole ring should be visible if the phenomenon is the same as that which Prof. Mach and I have photographed. In our cases a bullet travelling at a speed greater than that of sound, forms a hyperboloidal shell of compressed air round about it. Light waves passing nearly tangentially, but just entering the shell, are refracted inwards, and thus leave a black line when they fail to strike the photographic plate. As they strike the plate within this black line on a part to which other rays have come nearly direct, an extra bright line is formed within the dark one. That which is essential, however, for the formation of the dark line is the tangency of the incident light.

Now, in the case of a hemispherical explosive wave it is clear that the sunlight can only be tangential over a semicircle, and that the shadow of such a wave should be a semi-ellipse, the eccentricity of which would depend upon the altitude of the sun. There could be no true tangential shadow on the sunward side of the explosion. Observation, however, showed a complete ring. If, as has been suggested to me as possible, the explosive wave does not travel at equal speeds in all directions, but is retarded near the ground, the wave front near the ground might be sufficiently inclined for the sun's rays to be tangential over much more than a semicircle. On May 19, when I made the observation, the sun had an altitude of about 58°, but on April 6, when Mr. Ryves made his first observation, the altitude was only 45°.

Mr. Maxim, with his usual ingenuity, suggested that perhaps what was observed was not a sound shadow at all, but merely a progressive bending down of every blade of grass as the explosive wave passed by. This would no doubt occur, and might be visible, but it is difficult to see how so black a ring should be produced in this way.

The animatograph fails to show any black ring; and this is not surprising, as with the exposure of about 1/100 second the shadow would have to be at least 11 feet thick, in order that some part should remain obscured during the whole exposure. If the black line is just without an equal bright line, as in the bullet photographs, and both are taken in by an exposure, it is hardly to be expected that any definite result should be obtained. As a fact, there is clearly seen a circular light shading, which does—so far as one can judge from the supposed rate of working, and the known distances—expand at about the same rate as the observed shadow, but it is lighter than the ground and shaded, instead of being dark and sharp, as seen by the eye.

I feel that the imperfect account which I am able to give is of sufficient interest to appear in the columns of NATURE, but I hope that it may induce those who have occasion to detonate heavy charges to make any observations that opportunity allows.

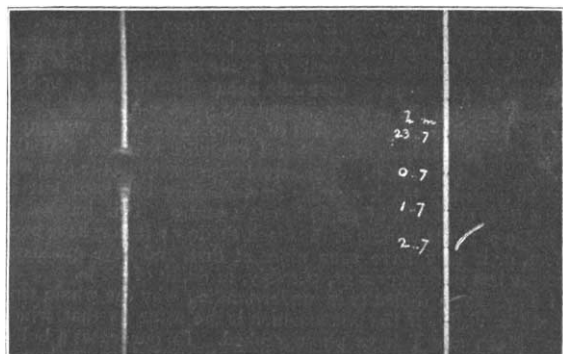
For instance, if the Ryves ring is only visible in direct and brilliant sunshine, that will be evidence in favour of the shadow theory. If it is equally visible when the sun is not actually shining, but when the sky is illuminated by numerous white clouds, that will be evidence of the grass theory.

I may add that our observations were made from the west, and at noon.

C. V. BOYS.

An Edinburgh Record of the Indian Earthquake.

A VERY interesting record of the recent earthquake at Calcutta is shown by the photographic apparatus of the bifilar pendulum of this observatory. A few very slight preliminary tremors commenced June 11, at 23h. 18m. G.M.T., and lasted for ten minutes. Violent oscillations then commenced suddenly, and lasted to June 12, oh. 33m., after which slighter tremors



continued up to 1h. 12m. The oscillations can be traced fully six times the measure of sensitiveness of the instrument on one side of the normal line, and four times on the other, which are together equivalent to a tilt of the supporting frame of about twenty seconds of arc. I enclose a negative of the original photograph, which, however, does not show all the minor details of the effect produced.

THOMAS HEATH.

Royal Observatory, Edinburgh, June 15.

Subjective Transformations of Colour.

MR. SHELFORD BIDWELL'S experiments, described in NATURE of June 10 (p. 128), remind me of a phenomenon which can be very easily demonstrated.

A disc is arranged so that a small sector, about one-sixth, is of a bright colour, while the remaining portion is white. If this be rotated slowly, the coloured sector appears to be followed by a ghost of the complementary colour: on quickening the rotation, the original colour is lost, and the whole disc appears to be of the complementary colour; but if the rotation be further quickened until flickering ceases, the original colour again predominates. In this way emerald-green may appear to change to pink, or crimson-lake to green.

This seems to be another instance in which the negative after-sensation is stronger than the original sensation. For the success of the experiment it is probably necessary so to adjust the rotation that (a) the negative sensation has a longer duration than the original sensation, and (b) the next original stimulus shall follow before the after-sensation has entirely faded. If the rotation be too rapid, the negative sensation has not time to develop, and only the original colour is seen.

Mason College, June 12.

F. J. ALLEN.

Planetary Orbits, illustrated by a Rolling Ball.

THE interesting article in NATURE, April 29, by R. W. Wood, on the orbits of a steel ball about a magnet pole, suggests to me that it may interest some of your readers to hear of another plan for showing these orbits, which, but for the slight resistance of the air, is very nearly theoretically accurate, and in which the proper initial velocities are easily produced.

The plan consists of causing a true steel ball—of, say, one inch or more in diameter—to roll on a hard and smooth surface of the proper form. The surface on which the centre of the ball moves is formed by the revolution of a part of a rectangular hyperbola about a vertical asymptote, and the real surface on

which the ball rolls is, of course, a distance equal to the radius of the ball from this imaginary surface at all points.

Fig. 1 is a vertical section, on a very small scale, in which the dotted lines show the rectangular hyperbola and its vertical and horizontal asymptotes, and the full curved lines show the actual surface on which the ball rolls; the interval between the dotted and full curved lines being equal to the radius of the ball.

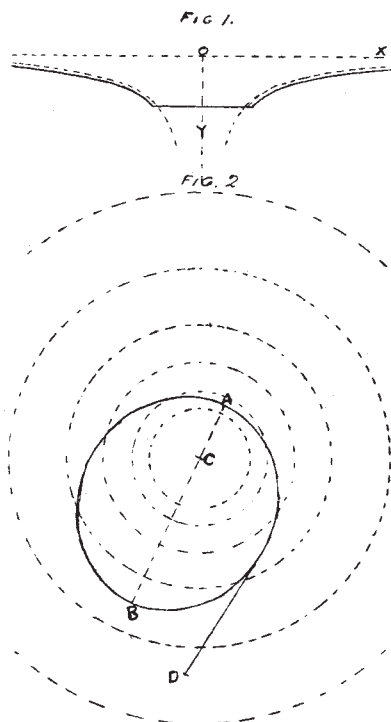


Fig. 2 is a projection on a horizontal plane showing contours of the hyperbolic surface at equal vertical intervals in dotted lines, and also one of the orbits referred to below in full lines.

Suppose the ball to be allowed to roll from the level of the horizontal asymptote, and directed so as not to come too near the centre (C) of the surface, it will describe a path whose projection on a horizontal plane is very nearly a parabola; and—as in the imaginary case of a comet coming from an infinite distance without initial velocity—its energy will be accurately in the inverse proportion to its horizontal distance from the centre of attraction, because the reciprocal of its distance from the centre is proportional to the vertical distance it has fallen, by the well-known property of the rectangular hyperbola. If the ball be allowed to roll from a point higher than the horizontal asymptote, it will describe a hyperbola; and if from a lower point, an ellipse.

To produce an ellipse having any given axis-major as A B, Fig. 2, let the ball roll from a point D, on the hyperbolic surface, whose distance from the centre C is equal to A B, and let it be directed with a straight-edge till it touches the desired orbit.

If we could neglect the resistance of the air and all other small resistances to the rolling of the ball, the actual energy, and therefore the velocity of the ball would be precisely what they ought to be to illustrate planetary motion; the direction of motion not being generally horizontal, however, and the orbit not exactly in one plane.

The fact that a part of a rolling ball's energy is rotational and part translational does not vitiate the experiment, because the proportion of the one part of the energy to the other remains constant.

In the case of a steel ball attracted by a magnet pole, the acceleration would appear to be inversely as some higher power of the distance than the square. In the case explained above, the acceleration is very nearly inversely as the square of the horizontal distance from the centre, and only differs from this proportion in being less, as the actual distance traversed by the ball exceeds its horizontal component, at any point; which may be a very small percentage.

GEO. ROMANES.

Craigknowe, Slateford, Midlothian.